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EXPERIMENTAL UPSETSTUDY ON BARRELING BEHAVIOUR OF A356 VARYING REINFORCED WITH GRAPHITE AND GRANITE DUST COMPOSITIES

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ABSTRACT

"An investigation has been performed into the effect of upset forging on commercially available A356, reinforced with Graphite and Granite dust in dry condition. The axi-symmetric specimens of cylindrical with aspect ratios 1.0 and 1.5 have been taken for the present work. The upset tests were performed at room temperature between two flat plates on a Fatigue testing machine (INSTRON Model: 8801). Experiments were carried out to generate data on the cold upset forging of solid cylinders for predicting the deformation to fracture. Due to practical difficulties in observing the crack initiation, the maximum deformation is limited to 50%. For A356 alloy and Composites, no cracks were observed. The effect of Flow stress and Flow strain with stresses namely; the Hydrostatic stress, axial stress and Circumferential of the analytical calculations were found to be in good agreement with the experimental calculations, with decrease in aspect ratio, the circumferential stress component increased monotonically".

***KEYWORDS:** Upset Forging, A356, Graphite, Granite & NSTRON Model 8801*

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Original Article

1. INTRODUCTION

"Metal forming is a significant plasticity working technique, used in many types of applications, especially in the industrial products of lightweight and high strength. Deformation is the change in shape of the work piece by the existence of frictional constraints between the dies. Friction at the contact faces retards the plastic flow of metals at the surfaces and in its region. A funnel shaped wedge of a relatively un-deformed metal formed at contact surfaces. Balance volume suffers high strain and bulges out in the form of barrel [1]. Upset forging or simple axial compression testing is useful for measurement of elastic and compressive fracture properties of both ductile and brittle materials. The true stress-true strain curves obtained from the compression test and tension tests on ductile materials coincide with each other, whereas this does not hold true for brittle materials, which are generally stronger and more ductile in compression than in tension".

Friction is one of the important parameters in metal shaping processes, as it influences metal flow, forming load, strain distribution, tool and die life, product surface quality and so on. The coefficient of friction in metal forming applications varies with the type of process. Commercially available FEA packages input the coefficient of friction as constant among, which is not a practical.

In metal working procedures, work piece undergoes appreciable change in cross sectional area. Engineering stress-strain curve does not give genuine indication of the deformation characteristics of a material, since; it is based on the original dimensions of the specimen, which change continuously during the test. Shape of

the specimen after compression largely depends on the aspect ratio (H/D) of the specimen [2]. The engineering strain 'e' is the ratio of the change in length to the original length [3–8]

2. FABRICATION OF COMPOSITES

Table 1: Chemical Composition of Al-Si alloy, wt%

Si	Mg	Cu	Fe	Ti	Al
6.5	0.4	0.05	0.09	0.06	balance

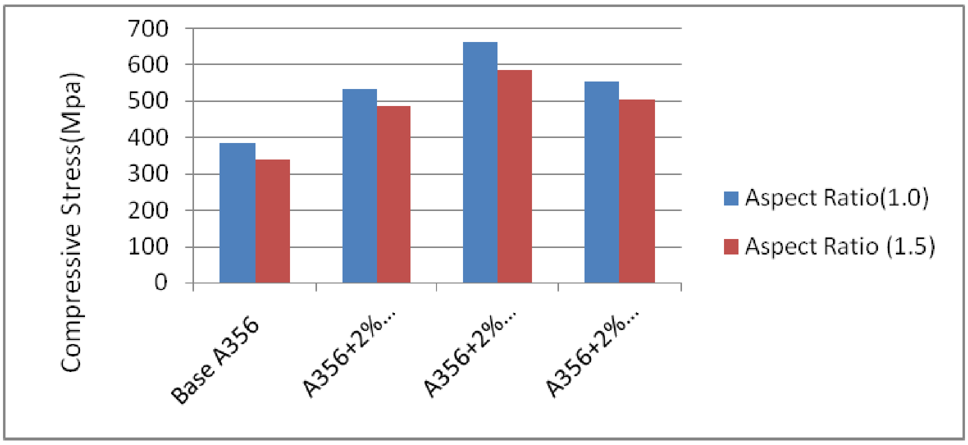


Figure 1: Compression Values after Deformation for 1.0 and 1.5.

Al-Si alloy was melted at 775°C under the protection of argon inert gas atmosphere. The reaction slag was skimmed from the surface of melt. Granite and graphite particles were added into the vortex formed during stirring. Al-Si alloy based composites were kept as constant and by varying the graphite 2% and granite 2–4 % in the form of 8inch long x 25mm dia and 8inch long x 22mm dia. castings. Homogenization treatment was carried out at 200°C for 24 h to relieve the internal stresses and minimize the chemical inhomogeneities, which may be present in the cast alloys. The cylindrical test specimens of size 12mm length x 12mm diameter with aspect ratio 1 and 18mm length x12mm diameter for aspect ratio 1.5 were machined from the castings for deformation studies.

“The upset tests were performed at room temperature between two flat plates on a Fatigue testing machine (INSTRON Model: 8801) as shown in figure 2. The compression dies of EN-31 grade isutilised for compression and also the sample was placed axi-symmetrically in between the dies. The tests were conducted at 10%, 20%, 30%, 40% and 50% deformations on the top surface of the Al-Si alloy and its composites, with a constant cross head speed to assess the deformation behaviour for two limiting values of aspect ratio 1.5 (to avoid buckling) and 1.0 (which is used in most of the forging applications)”.

3. EXPERIMENTAL STRAIN AND STRESS ANALYSIS

“Surface strains, (ε_θ) and (εz) were assessed for the geometric mid-sectional grid of the specimens (figure 2). Upset tests with friction produce curved strain paths. Some of these equations for eight strain paths obtained from different specimens. The ends of the strain paths represent the fracture or maximum Deformation points. Joining of all these points of all strain paths gives the workability limit for the alloy considered. The deviation of slope of the experimentally determined relationship between axial strain εz and circumferential strain (hoop strain) ε_θ, from that relating to homogeneous

deformation, represents barreling. This deviation was less when the specimen- die interface friction was low. The strain paths for H0/D0=1.0 are much sleeper than H0/D0 =1.5 in indication friction conditions. For ring specimen, the flow of the material was dominant on the outer periphery compared to the inside periphery of the mid-section. The deviation from homogeneous deformation was watched for the specimen aspect ratios of 1.0 and 1.5".

Figure 2: Shows the Deformation of Specimen with INSTRON.

"The knowledge of the experimental plastic strain history allows the experimental evaluation of stress components with the undergoing deformation (Rao *et al.*, 2009). Effective stress ($\bar{\sigma}$), and stress components σ_θ, σ_z and σ_H as a function of effective strain ($\bar{\varepsilon}$) calculated from grid measurements of images obtained from vision technique for A356 and its reinforcements, under specified friction condition for aspect ratios of 1.0 and 1.5 of solid cylinder. In an idealized situation of uniaxial compression, the hoop stress σ_θ, is zero and the axial stress (σ_z) is equal to the yield stress (σ_0). Under this condition, the hydrostatic component of the stress (σ_H) would be equal to $\sigma_Z/3$ and would always be compressive; a state of instability will never occur in homogeneous deformation. Hence, according to an instability theory of fracture, ductile fracture will never occur in homogenous deformation. On the other hand, if the friction between the specimen and platens is such that the deformation departed from the homogeneous case, barrel is developed. The tensile circumferential surface stress component (σ_θ) is non-zero and the hydrostatic component of stress (σ_H) become less compressive and in some cases tensile.

The present results referring to figure 3 to 6 shows that with the increasing friction constraint, the hoop stress component (σ_θ) increasingly becomes tensile with continued deformation. The increase in its value was found to be more, in case of specimens deformed under low aspect ratio compared to the high aspect ratios. On the other hand, the axial stress (σ_Z) increased in the very initial stages of deformation but started becoming less compressive immediately, as barreling developed. For un-fractured specimens, the axial stress (σ_Z) will always be compressive. However, for the specimens where surface fracture occurred, both σZ and σ_H stresses components became less and less compressive, as deformation progresses and become tensile. The hydrostatic stress involves only pure tension or compression and yield stress is independent of it. But, fracture strain is strongly influenced by hydrostatic stress (Dieter, 1988; Brozzo, *et al.,* 1972). Increase in friction constraint and decrease in aspect ratio caused hydrostatic stress to be tensile and instability starts. As the hydrostatic stress becomes more and more tensile, a state of tensile

instability will occur. The transformation in nature of the hydrostatic stress from compressive to tensile depends on the shape and size of the specimen and the frictional constraint at the contact surface of the specimen with the die block".

"From the observation of figure 3 to 6, showing hydrostatic stress as a function of effective strain, it was concluded that for the same amount of strain, hydrostatic stress changes quickly from compressive to tensile for small aspect ratios. The extent of deformation from instability to fracture is large. However, this post instability strain to fracture can be increased by changing the microstructure via proper heat treatment".

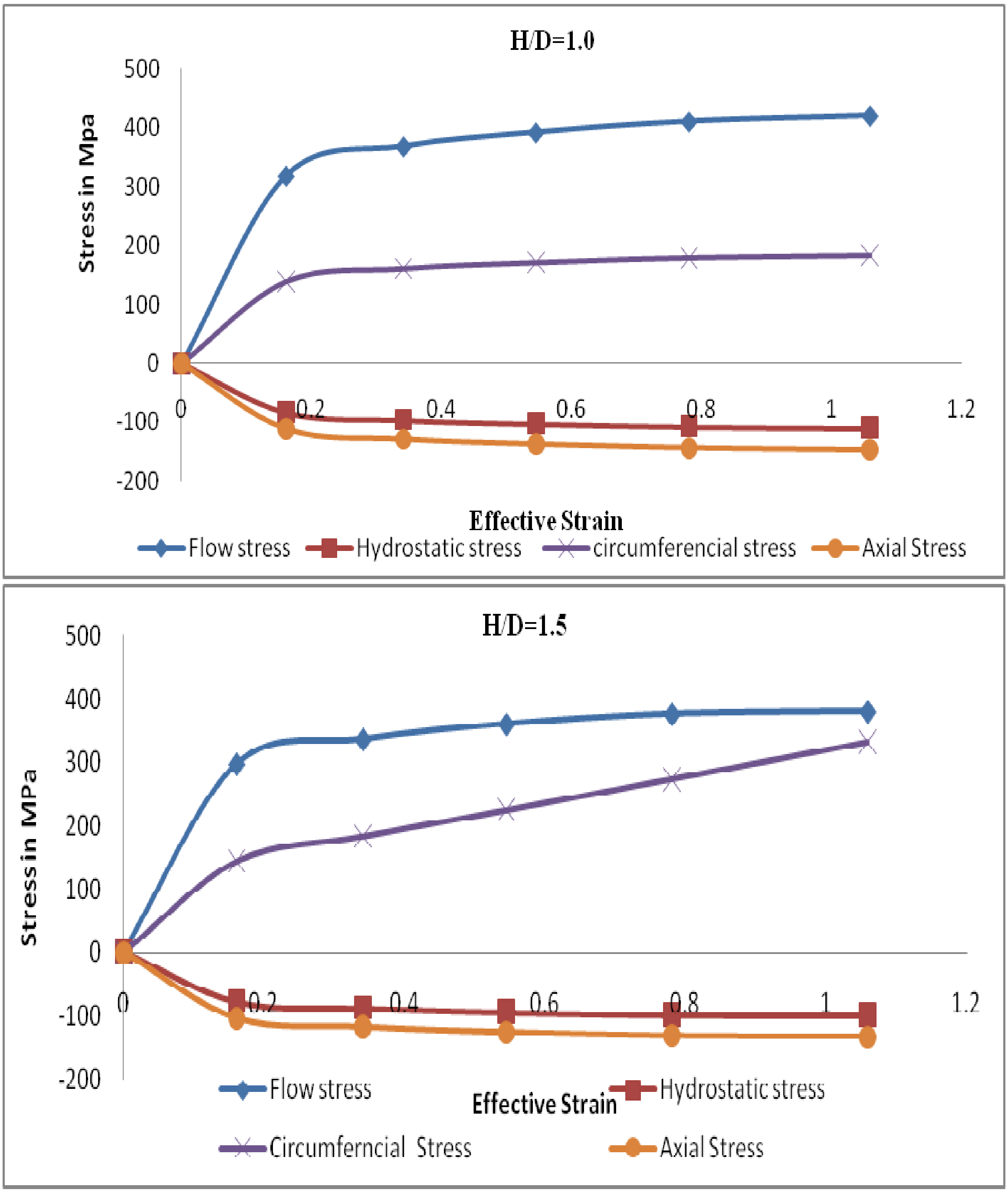


Figure 3: "Effective Stress $\bar{\sigma}$, Stress Component σ_0, σ_Z, and σ_Z as a Function of Effective Strain $\bar{\varepsilon}$ for A356 H/D=1.0 and H/D=1.5".

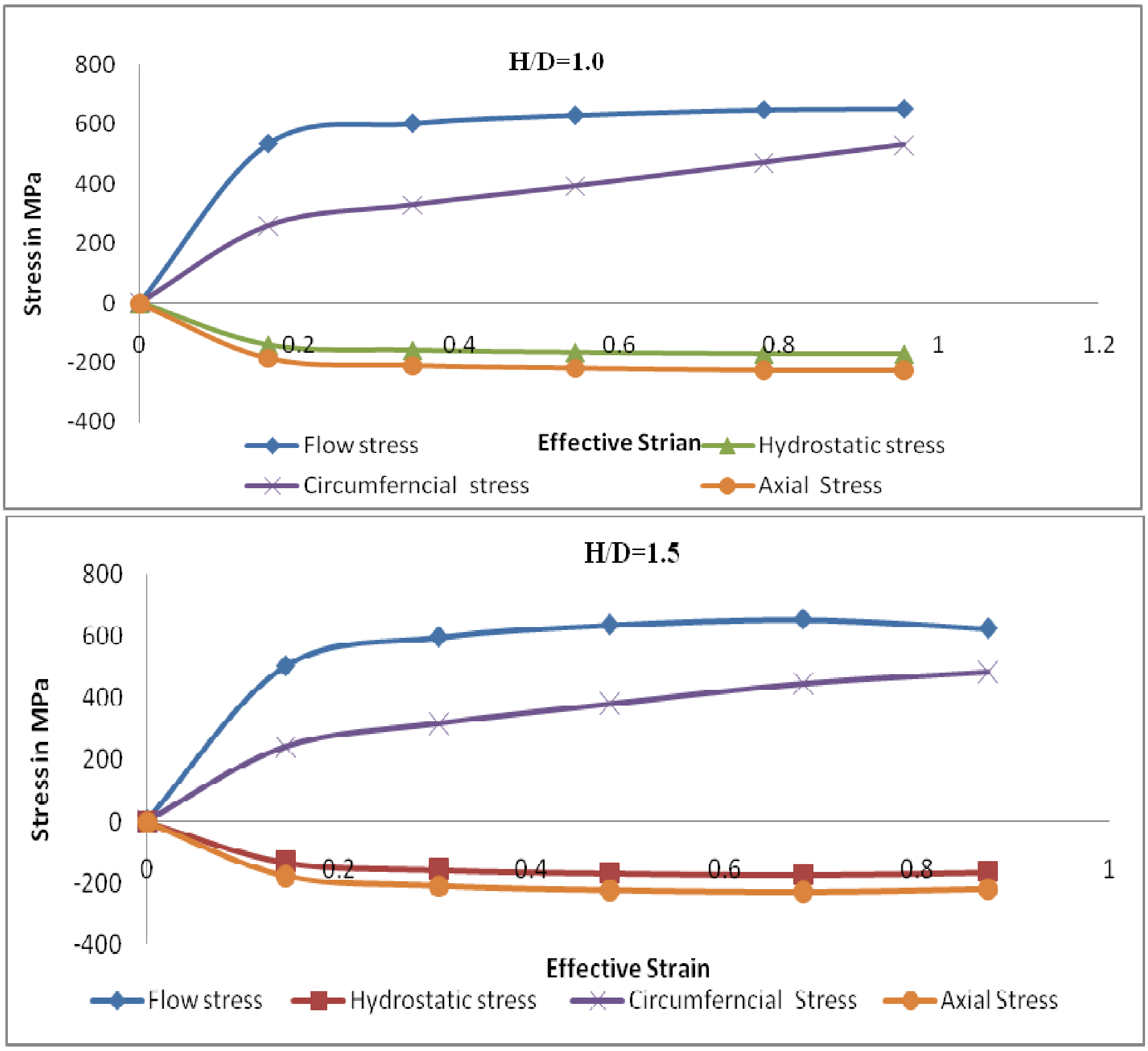
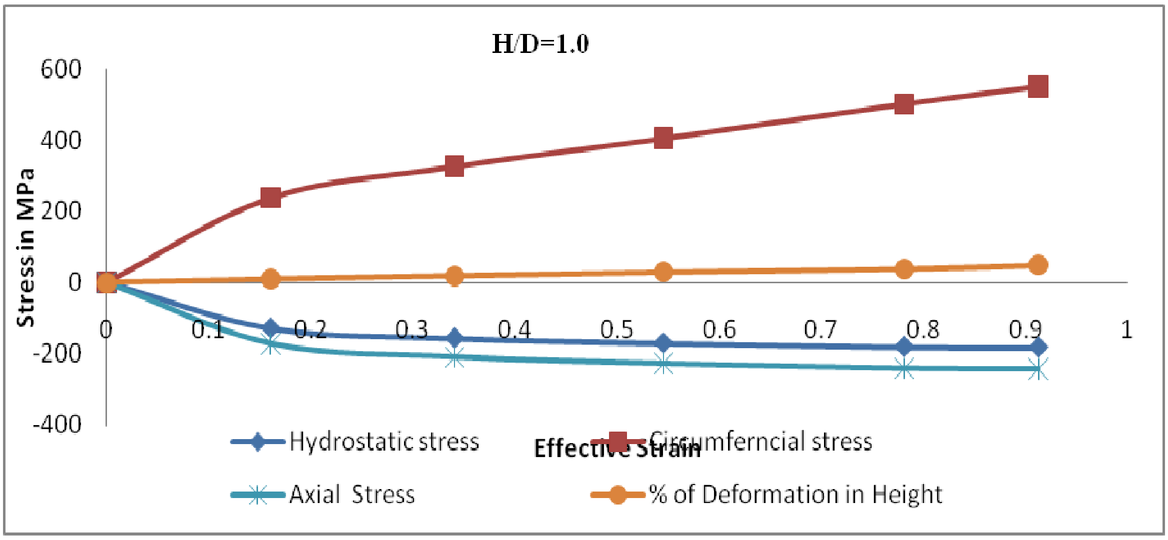


Figure 4: "Effective Stress $\bar{\sigma}$, Stress Component σ_θ, σ_Z, and $\sigma_Z$as a Function of Effective Strain $\bar{\varepsilon}$ for A356+ 2% Graphite H/D=1.0 and H/D=1.5".



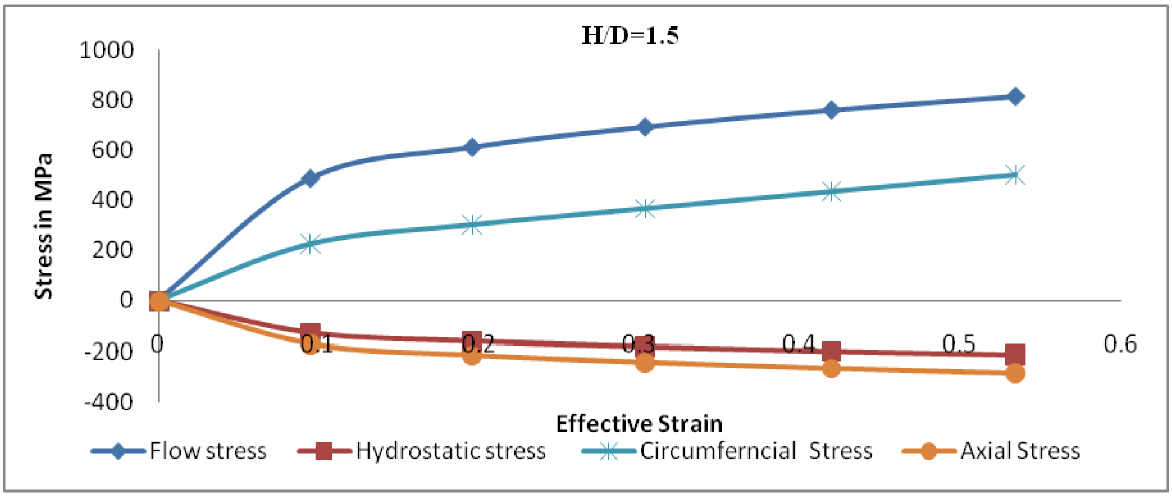


Figure 5: “Effective Stress $\overline{\sigma}$, Stress Component σ_θ, σ_Z, and σ_Z as a Function of Effective Strain $\overline{\varepsilon}$ for A356+ 2% Graphite + 2% Granite Dust H/D=1.0 and H/D=1.5”.

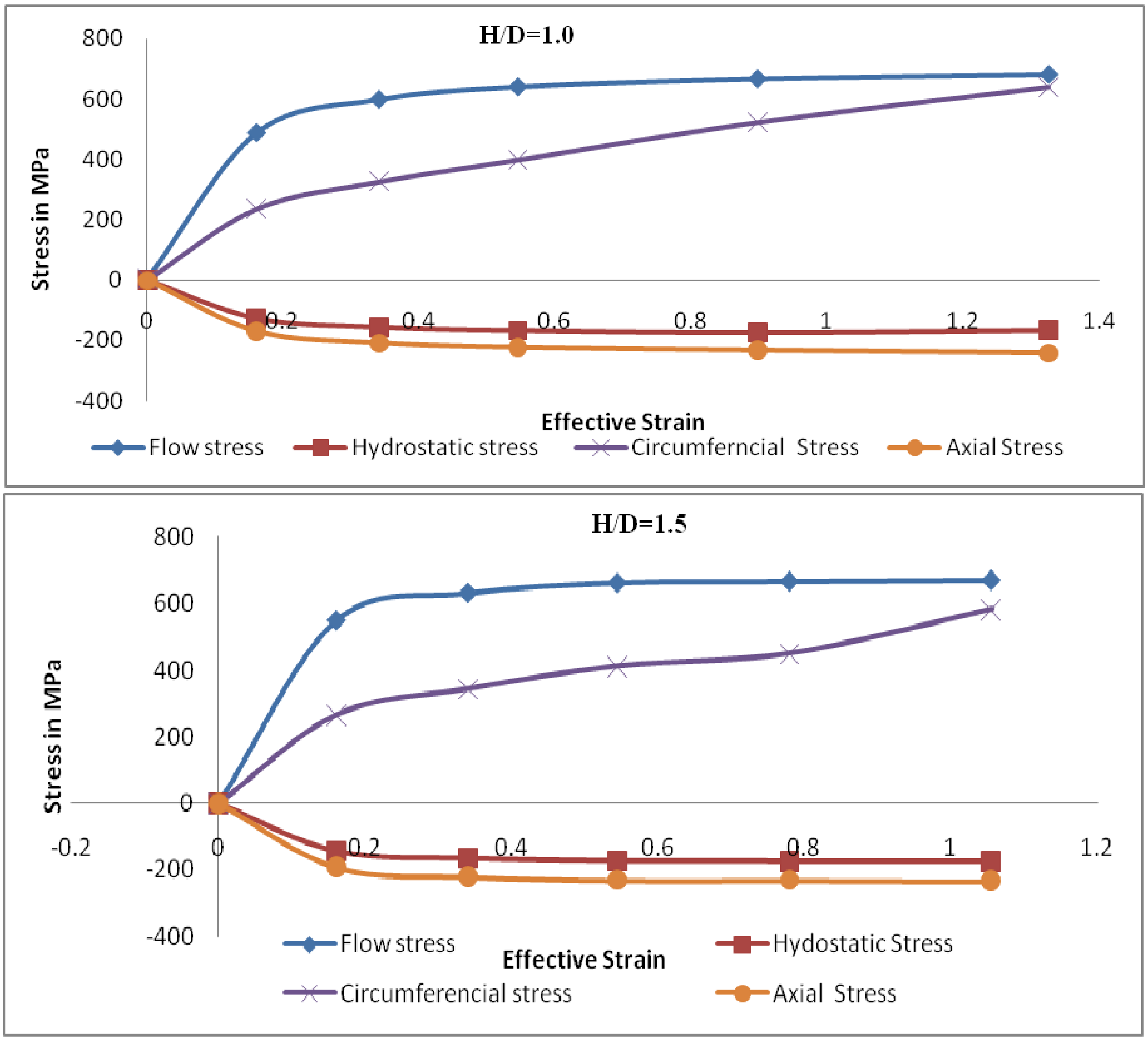


Figure 6: “Effective Stress $\overline{\sigma}$, Stress Component σ_θ, σ_Z, and σ_Z as a Function of Effective Strain $\overline{\varepsilon}$ for A356+ 2% Graphite + 4% Granite Dust H/D=1.0 and H/D=1.5”.

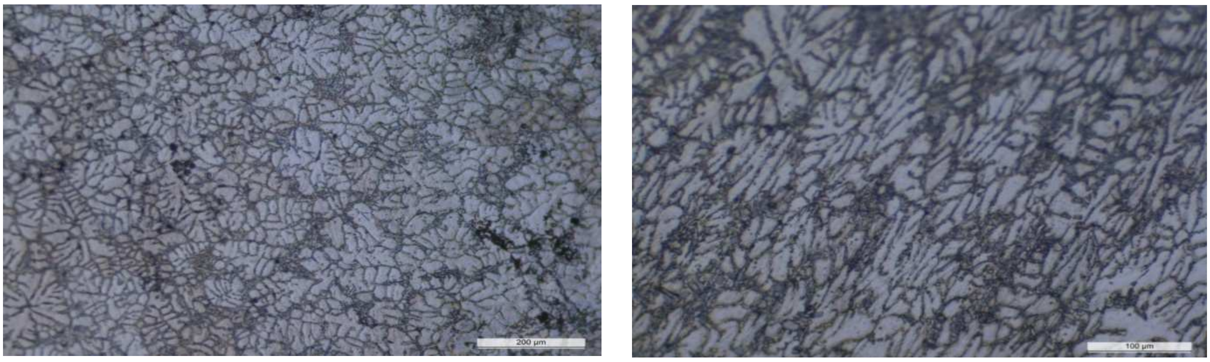


Figure 7: (a) Before Compression A356 Alloy (b) After Compression A356 Alloy (Elongated Grains).

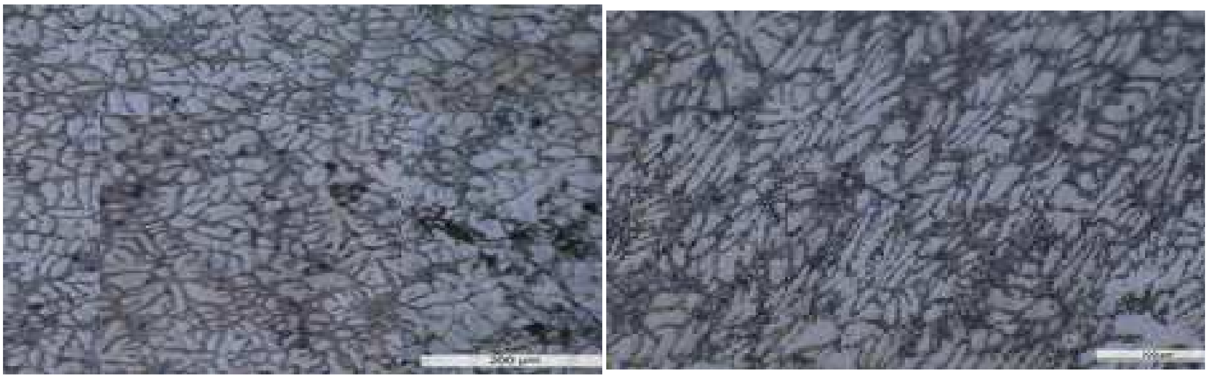


Figure 8: (a) Before Compression A356 + 2% Graphite and 4% Granite Powder Composite (b) After Compression A356 + 2% Graphite and 4% Granite Powder Composite (Elongated Grains).

In the present work, the upsetting tests were performed in dry condition for predicting the deformation to fracture. Due to practical difficulties in observing the crack initiation, the maximum deformation is limited to 50%. For A356 alloy and graphite 2% and granite 2–4 %, no cracks were observed.

A continuous increase in compression strength values with increased reinforcement content, which is in tune with that of tensile behaviour discussed. The grain structures of A356 alloy before and after compression are depicted in figures 7 and figure 8. Before and after compression of A356 + 2% Graphite and 4% Granite powder composite, it is observed that the grain structure is elongated after the compression.

4. CONCLUSIONS

- "For both alloy and composites, effective strain increases and the circumferential stress component becomes tensile with continued deformation.
- The increase in circumferential stress component value was observed to be more, if there should be an occurrence of specimens deformed for lower aspect ratio compared with the higher aspect ratio conditions.
- With decrease in aspect ratio, the circumferential stress component increased monotonically. At the beginning of deformation, axial compressive stress increased in magnitude but as the deformation progress, the magnitude reduced. Hydrostatic stress also reduced in magnitude as the deformation increased. Increase in friction constraint and decrease in aspect ratio caused hydrostatic stress to be tensile".

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